Special Report

Overview and Prospects of the USDA-COA Cooperative Program in Agricultural Sciences

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ABSTRACT

This report provides an overview of the background and history of the signing and implementation of the Guidelines for a Cooperative Program in the Agricultural Sciences between the American Institute in Taiwan (AIT) and the Taipei Economic and Cultural Representative Office (TECRO) in the United States, signed in January 1986. AIT works in association with the United States Department of Agriculture (USDA) in administering this cooperative program, while TECRO performs a similar function in affiliation with the Council of Agriculture (COA). Bilateral annual meetings were held to review the cooperative program and periodically, the main theme of the future cooperation and mutual beneficial priority areas were discussed. Modification and amendments to the program were then made on agreed issues. In 1997, a symposium was held in Taiwan to review the results and status of this program. Up to this year, a total of 99 cooperative research projects in the field of crops, animal husbandry, forestry, aquaculture, and biotechnology have been conducted. Except for a number of ongoing projects that usually cover a period of 3-4 years, most of the projects that have been duly completed received satisfactory remarks from peer reviews and were published. This report also attempts to highlight the research activities and achievements of the collaborative projects. While the importance of this cooperative program has long been recognized, additional priority areas were identified and proposed, especially in the context of biotechnology as a complementary input to future cooperative programs.

Key words: Overview and prospects, USDA-COA Cooperative Program, Agricultural sciences.

INTRODUCTION

The Guidelines for a Cooperative Program in the Agricultural Sciences between the American Institute in Taiwan (AIT) and the Coordination Council for North American Affairs (CCNAA), presently the Taipei Economic and Cultural Representative Office (TECRO) in the United States, was signed in January 1986. These Guidelines were designed to promote cooperation between scientists from the United States and Taiwan Republic of China (ROC) pursuant to the Agreement dated September 4, 1980, between the AIT and the CCNAA (hereafter referred to as TECRO). The Taiwan Relations Act (Public Law 96-8, April 10, 1979) authorized the continuation

of commercial, cultural and other relations between the people of the United States and the people of Taiwan. Such relations are conducted by or through AIT, a non-profit organization incorporated under the law of the District of Columbia, and TECRO, a non-government organization established to provide assurance and take actions on behalf of the people of Taiwan. AIT works in association with the United States Department of Agriculture (USDA) in Washington, D.C. in administering this cooperative program, while TECRO performs a similar function in affiliation with the Council of Agriculture (COA) in Taipei, Taiwan ROC. The following is an overview of the main features of the Guidelines and the amendments adopted in the course of implementation of the cooperative program.

Program Goals

When it was initiated, the cooperative program was designed to:

- Increase the contacts and cooperation among agricultural scientists and institutions of agricultural research and higher learning between the two sides, USDA and COA;
- Provide researchers and institutions with opportunities to exchange information, ideas, skills, and techniques;
- Enhance opportunities to collaborate in solving problems of common interest; and
- Utilize special facilities or research opportunities available.

Cooperation may be in any of the broad areas of basic and applied agricultural sciences, including forestry and agricultural economics. The types of cooperative activities may include the exchange of scientific information, scientific visits, seminars and workshops, and cooperative research.

Implementation and Coordination

As stipulated in the Guidelines, AIT and TECRO shall coordinate the activities agreed upon under these Guidelines, and USDA and COA shall implement them. Each side shall designate a program coordinator to be responsible for the overall coordination of cooperative activities under these Guidelines. Each side must also identify a topic coordinator.

Initial Areas of Cooperation

In 1986, the following topics were considered as priority areas for initial cooperative activities:

- New cropping and pest management techniques with emphasis on biological control;
- New production methods that conserve resources while maintaining or increasing yields, and systems for effective use of soil, water and air resources;
- Germplasm of plants, animals and organisms that have significant value in agriculture and forestry;
- Basic research and biotechnology applications for plant and animal production and protection;
- Post-harvest technology; and
- Aquaculture.

Additional Areas of Cooperation signed in 1989

The following topics have been identified as additional areas of cooperative activities, which took effect in September 1989:

- Product marketing and development;
- Forest management;
- Research and professional enhancement

involving natural reserves and wildlife management; and
- Professional enhancement and assistance involving agriculture, forestry, land preservation, land planning and urban development.

Amendments to the Areas and Scope of Cooperation were signed in 2001.

Selected priority areas for cooperation may include, but not limited to:
- Sanitary and phytosanitary technology;
- Environment, natural and marine resource management;
- Research and management of bio-technology products;
- Technology transfer and food safety;
- Horticulture and crops; and
- Animal waste management.

Review Meetings

As a usual practice, AIT and TECRO program coordinators met periodically, at time and places of their choosing, to review and adjust the program of cooperation, recommend projects to be funded, and coordinate administrative matters.

Funding

Funding of cooperative activities under these Guidelines shall be carried out on the basis of mutuality, reciprocity, and flexibility. In general, each side shall fund the cost of its participation in cooperative activities and may, as it chooses, provide full or partial support for participation in these activities by scientists of the other side. Decisions on funding for joint activities shall be made by mutual agreement. Subject to availability of funding, in particular, each side shall contribute to the cooperative activities as follows: USDA shall provide airline tickets and health insurance for participating scientists, while TECRO shall provide funding for the collaborative research activities in Taiwan, and per diem for traveling scientists from Taiwan.

Memorandum

Under the umbrella of the original Guidelines, AIT and TECRO have, in addition, signed three more memoranda as follows:
- Memorandum on Cooperation in Enhancing Commodity Situation and Outlook Reporting (February 1991)
- Memorandum on Cooperation in Forestry and Natural Resources Conservation (July 1991)
- Memorandum on Cooperation in Soil and Water Conservation (October 1992)

OVERVIEW OF PROJECT IMPLEMENTATION, 1997-PRESENT

The projects that have been implemented from the onset of the cooperative program in 1986 to date and other related information are presented in the Appendix. A Symposium for the Review of COA-USDA Agricultural Science Cooperative Program was also organized and held at the Taiwan Agricultural Research Institute (TARI), Taiwan ROC on May 5-6, 1997 for a comprehensive evaluation and assessment of the implementation of the collaborative projects. Likewise, all the abstracts of the implemented thematic subjects were compiled into a symposium proceeding. To give an overview of the progress and achievements of the collaboration projects conducted, following are brief descriptions of the research findings achieved from 1997 to date:

1. Plant Science

Pest management

Research on coordinate management and control of fruit flies

Several notorious species of fruit flies are considered as some of the most destructive agricultural pests in warm weather and tropical environment. Fruit flies have been widely placed in the watch list as one of the most important quarantine insect pests, in order to prevent their movement across national borders. They can also spread through export/import of produce and travel activities. With the increase in global trade, all countries are seeking for the most effective tools to deal with these pests – whether to control them within their vicinity or to keep out these potential invasive species.

Some useful results have been accumulated to hasten fruit fly management techniques by adopting the area-wide approach which aims to coordinate the efforts of all stakeholders, including farmers as partners. The fruit fly control research has been further improved by the team of scientists from Hawaii and Taiwan. Sixteen fruit fly control districts were established by the end of 2004. In each district, the fruit fly density data and variation of fruits and fruiting season are collected and analyzed for planning the control scheme and necessary timing adjustment. To disseminate improved technologies, the farmer education program has been extended to speed up the modernization process and provided demonstration tools for field application. The newly introduced protein bait, GF-120, has been registered and demonstrated for both fruit fly and melon fly control. In addition, the application of GIS/GPS techniques has also been incorporated to sharpen the precision of the database analysis for the coordinate control practices. The efficacy of the coordinate area-wide control approach has prompted the neighboring area of the demonstration fields to join in to form and enlarge the new areas for fruit control. Likewise, these results of the collaboration among scientists from both sides in terms of exchange of information and development new technologies were much appreciated, in addition to the methodological outcomes.

Biological control of insect pests on vegetables in pipe house

In Taiwan, crucifer crops are primarily cultivated in pipe houses. Insect pest surveys in pipe houses revealed seven species of pests, mainly aphids, thrips, mites, whiteflies, and leaf miners. Possibilities of improving current control methods used in pipe houses are to be investigated by using biological control as a viable alternative. A pest management system should also be developed to integrate the use of natural enemies, such as parasitoids and predators, with other compatible methods. Collaboration research for information on the basic biology and ecology of the parasitoids and predators have been collected for eventual use in the field or in pipe houses, to evaluate the effectiveness of these natural enemies in controlling insect pests on vegetables. In addition, further clarification is being made on the occurrence of the key insect species, their natural enemies, and their population fluctuations. Then, the species, timing, and quantity of the natural enemies released will be assessed for determining the cost-effectiveness of the biological control program and a biological control strategy will ultimately be developed.

Monitoring occurrence of late blight and its management

Late blight caused by *Phytophthora infestans* is one of the most destructive diseases of potatoes and tomatoes worldwide. Survey results revealed numerous pathogenic isolates, 113 isolates of which were found aggressive to both tomato and potato. This project will be continued to assess the occurrence and severity of late blight in tomato and potato crops through surveys in Taiwan, and to collect isolates and characterize them according to genotype, mating, and metalaxyl sensitivity.

Monitoring and development of detection kits for amaryllis plants

Many species in the amaryllis family are considered a good genetic resource and have great potential to be transformed into novel ornamental crops. However, amaryllis plants are vulnerable to many kinds of virus disease infection that threaten their production. The project succeeded in the identification and characterization of seven viruses infecting amaryllis plant species. Four of these seven viruses are new records in the literature and were named by the research team. In addition, the collaboration project has successfully developed detection kits and protocols that are essential to the development of virus-free amaryllis plant propagation system. These valuable results can be further explored for future development of commercial amaryllis ornamentals.

Potential application of Family 19 antifungal chitinases in crop management

Technological experiments were made to prepare a *Streptomyces*-derived Family 19 antifungal chitinase gene (SGS3 chi F) transgenic plant for use in disease-resistance breeding and practical crop cultivation using tomato as a model system. A preliminary survey on the expression of the gene with colloidal chitin application indicated that SGS3 chi F was among the bacterial chitinase genes preferentially expressed. A screening survey indicated that the enzyme is unique among all 16 antifungal chitinolytic *Streptomyces* tested. The serological correction and the size similarity suggested strongly that they evolved from the same biological origin. These results are very useful for future breeding of disease-resistant tomato through the transformation of bacterial chitinase genes.

Crop and nutrition

Antioxidant activities in vegetables

Increased vegetable consumption has been widely promoted in recent years because of their value to human diets by providing basic nutrients, fibers, minerals, vitamins and phytochemicals with antioxidant activities. An appropriate recommendation of particular vegetables or groups of vegetables would help to increase the consumption of antioxidants in the diets. So far, this study has evaluated 127 species of vegetables for antioxidant activities. This project has produced valuable results which can be directly used in the fields for systematic comparison of antioxidant activities in vegetables and useful information for selection of vegetables and methods for antioxidant supplements and related studies.

Antioxidant activities of tropical fruits

A total of 47 fruits were collected and analyzed for their antioxidant activities as measured by their ascorbic acid phenolic contents. The result revealed that papaya and guava had the highest ascorbic and total phenolic contents.

Floriculture

Post-harvest physiology of anthurium cut flower

Studies on the physiological responses and post-harvest handling of anthurium cut flower revealed that the cut flower is chilling sensitive. Among 11 anthurium cultivars evaluated as to their suitability for marine shipment, only five of them did not show any significant loss of quality or vase life. As to chemicals, benzylaminopurine (BA) was the most effective for most of the cultivars. However, BA induced spathe greening that lowered the cut flower quality. Meanwhile, the reduction in vase life due to chilling can be compensated for by BA treatment.

Molecular breeding of flower color

Some useful genetic materials were made using manipulation of pigment gene cloning, transformation, gene transfer, and mass propagation of transgenic plants to form new floral plants and flowers. This project aimed to develop rare yellow flower colors of chrysanthemum, caladium and anthurium using a transgenic approach. The chalcone isomerase (CHI) gene has been successfully transferred into chrysanthemum in either sense or anti-sense direction. The flowers in transgenic "Red beauty" chrysanthemum turn the color from red to yellow, indicating that the accumulation of yellow narigenin chalcone is due to the co-suppression of the endogenous CHI, which provided an alternative way for flower color to be engineered through the transformation of the CHI gene. This study was the first report on successful gene transfer to obtain yellow-color flowers and ornamental leaf plants which can be ultimately used in the development of commercial cultivars

2. Food Science

Development of biochips for detection of pathogenic bacteria in meat products

Some useful technologies have been developed by using biochips for the rapid identification of pathologic bacteria in meat products and in foods. So far, 15 oligonucleotide probes were selected and spotted on the nylon strip to determine the oligonucleotide array hybridization patterns. More than 179 strains belonging to five major pathogenic bacteria genera could be identified by using the developed oligonucleotide arrayed biochips. For such biochip, adding more oligonucleotide probes may allow the detection of more numbers of bacteria without significantly increasing the chips complexity. These results are extremely useful for the development of oligonucleotide arrayed biochips for the rapid detection of pathogenic bacteria in meat products.

3. Animal Science

Animal biotechnology

Bovine ephemeral fever

Surveys revealed that Taiwan has had eight recorded epizootics, in which the death and culls rose from about 5% in 1967 and had reached to 50% in 2002 in an important outbreak. This study evaluated the population immunity in Taiwanese dairy cows and worked on the development of a rapid diagnostic ELISA kit and new vaccines. Results showed that a single-dose vaccination induced serum neutralization antibody (SNA) level to rise and fall to a minimum after 6 months, which coincided with a focal outbreak that occurred in

September. These results provided precious information on the timing and frequency of vaccination for better prevention of the focal outbreak of the disease.

Generation of transgenic-cloned calves

This study on technological improvement for animal cloning achieved remarkable outcomes through the efforts of the collaborators from both sides, Professor Jerry Yang, the world famous expert in cow clones from the University of Connecticut, and Winston Cheng from National Taiwan University. The preliminary successes of cloned mammals, including pig, cow and dairy goat, were highly recognized in many academic papers and newspapers. The collaboration has already enhanced and provided more precious information for cloning technologies, which are and will be, inevitably intensively used for animal breeding and production.

Development of rapid diagnosis of Toxoplasma infection

Some useful results have been obtained suggesting that the recombinant fusion protein of P30 gene has antigenic epitopes with the specificity of *Toxaplasma gondii*. This recombinant protein exhibited potential to develop into a sensitive and specific antigen for rapid diagnosis of toxaplasma infection simply from blood examination.

Control of avian leucosis

There is an urgent need to develop a specific antigen detection method for Subgroup J avian leucosis virus (ALV-J) since the group-specific antigen detection is unable to distinguish exogenous from endogenous viruses. The project has successfully developed a technology for obtaining monoclonal antibodies specific to ALV-J. This antibody has been used for diagnosing ALV-J infection in chickens and the monoclonal antibody chip can be further developed for use in rapid diagnosis of avian leukosis.

Development of reliable methods for drug residue detection

In this study, a set of enzyme-linked immunosorbent assay (ELISA) kit has been developed with its detection sensitivity between 0.5 to 1 ppb. Furthermore, there is no cross reaction with major antibiotics. These results are valuable as inputs in designing new detection kits, which is projected to grow fast in the coming years.

Facility improvement and professional enhancement

The objectives of this project are to develop standard operation procedures for an animal disease diagnostic center, especially for the negative-pressured animal necropsy facility and training of animal disease diagnostic personnel. The project has formulated standard operation procedures for a negative pressured necropsy facility, laboratory tests for bovine spongiform encephalopathy, and tests for rabies. In addition, a general guideline for necropsy was provided. For training of personnel, the Animal Health Research Institute is planning to send its pathologists to enroll in pathology residency programs in the US for further advancement of pathology knowledge and competency.

4. Aquaculture

Improvement of Pacific white shrimp production

Some useful outcomes have been achieved revealed that shrimps derived from white spot disease virus (WSSD) resistant brood-stocks show a significantly higher survival rate than those of the control shrimps. It was also shown that stock obtained from rapid growth strain of Pacific white shrimp demonstrated a superior growth rate than those of regular shrimp stock. Furthermore, investigation made in clarification of the efficacy of B – Glucan produced by several fungi showed a significant contribution on the survival and growth rates of cultured Pacific white shrimps.

Water quality control of recirculation aquaculture system with algae culture

The goal of this project was to develop an integrated aquaculture model characterized by water-recirculation and low-cost production of healthy shrimp and oyster. Some useful results have been achieved showing that the integrated shrimp algae culture system was effective in controlling water quality and diseases, as well as the cost efficiency in terms of shrimp production and maintenance of the water recirculation system in operation. Oyster is not an essential component for the integrated system.

5. Forest Management

Carbon sequestration

Trees are the main sequestrator of carbon dioxide into organic carbon in the forest, making it to become part of the biomass, a most efficient natural way of carbon sequestration to alleviate global warming. Thus, proper forest management can enhance the capability of forest to sequestrate carbon and reduce accumulation of carbon dioxide in the atmosphere. The project aimed to establish a Taiwan natural forest optimal management model under the ecological management principles. Experiments conducted in a natural cypress stand showed that the maximization carbon in the steady state without any treatment could be stored 230 ton/ha. Furthermore, this stand could still store 176 ton/ha under the treatment with mild selective cutting and 13 ton/ha for the timbers after cutting for the end use. In economic performance, the stand could generate over 21 million NT$/ha for timber revenues and the soil expectation value could exceed 90 million NT$/ha. Using these models, significant benefits could be derived from the forests. These results are very useful for quantified management of natural forests, and to establish a reasonable norm for forest resources management taking both economic development and ecological balance into account.

DISCUSSION

I hope that the overview and the brief project descriptions provided everyone with a better understanding of the program, toward further enhancing the ongoing collaboration and developing new themes for our future cooperation in agricultural sciences. In this presentation, the questions that I want to pose everyone are: What impressions and inspiration could we draw from the experiences of the past cooperative program to enable us to further improve our future collaborations? How are we going to enhance and efficiently manage the collaboration that have become wider and more comprehensive to encompass various research fields in agricultural sciences, especially in the context of biotechnology and its impact on trade concerns toward coping with the current changes of the time? I envision this bilateral cooperative program to be more focused and managed more smoothly, and to better contribute to scientific and technological advancements in the years ahead. While our 20 years of

collaboration have been fruitful and rewarding in terms of formulation, identification of priority areas and implementation of the collaborative projects, greater challenges lie ahead especially in responding to structural changes in global agriculture.

Please allow me to elaborate a little bit more on the implementation and management in the early years of the cooperative program. Just imagine how much different it was then in terms of communicating among the working teams from the two sides, when east met west at the beginning. There were differences in language, status of science and technology development, calendar fiscal year in budget allocation, administrative regulations, and small things like project proposal and management, among others. But the most important thing is, we were able to manage it through and made things moving rather smoothly. I was fortunate from the beginning to be deeply involved in the cooperative program, designated as program coordinator by the COA side from 1986 until 2000. I still cherish to these days the memorable times I had working with Dr. Walker of USDA, my first counterpart coordinator for 6 years until his retirement. He was later succeeded by Dr. Bellis and Dr. Kramer-Leblanc. We worked closely in taking charge of all the coordination aspect of the program, from consultation on cooperative project identification, research proposals, monitoring project progress, and keeping track and review of the final completion report, and all these were done on an annual basis. The cooperative program has allowed researchers from numerous academic and government institutions in both the USA and Taiwan to jointly carry out 99 projects under the broad aspect of agricultural sciences, as shown in the Appendix. A total of 99 projects have been implemented classified into plant science (37), food science (9), animal science (24), aquaculture (16), and forestry (13), respectively.

This is the second workshop to be held for the purpose of reviewing the progress and achievements of the cooperative programs, the first workshop held eight years ago in 1997. Following are my comments with respect to prospects for further enhancing future collaborations under the USDA-COA cooperative program in agricultural sciences.

Enhancing Implementation and Management of the Cooperative Program

Each year during the program implementation, the program coordinator from the USDA visited Taipei, usually at the later part of the year, to join the working team in the project formulation. Summary titles and project descriptions were mailed to USDA in advance for initial assessment. At the meeting in Taipei, these project titles and summaries were reviewed and reasonable cuts were made on the budget based on deliberations by the group. By the end of February of the following year, the projects selected were submitted for peer review in Taiwan. Then the projects were sent to the US also for peer review. Usually by the end of April, mutually agreed upon projects were identified and approved, so that the approved project funding and implementation could match with the government budget fiscal calendar year starting from July 1 ending in June 30 of the subsequent year. The research projects were carried out in Taiwan, and the US collaboration counterpart scientists acted in advisory capacity making occasional visits to review or discuss the project progress. On certain occasions when Taiwan scientists needed to travel to the US, the latter side paid for the international travel.

Since the government fiscal calendar has now been changed to follow the normal calendar starting from January 1 and ending in December 31, it is advisable that the timing of bilateral meeting and project submission cycle be adjusted accordingly for a more efficient project management. It is also important that in order to ensure accountability of project monitoring, progress reports are required twice a year. Upon project completion, a final report is prepared and published. To warrant better execution, each cooperative program will be given support in duration of 3-4 year cycle but subject to annual progress review. If the problem addressed by a program is solved or is no longer a high priority after the cycle, it can be replaced by a new, much higher priority program. Toward harnessing the greatest benefit of the revised project, management system must be given better access to information about the cooperative research programs. It is suggested that a database be included as part of the Agricultural Science and Technology Information Management System which was established by the Agricultural Science Information Center. Likewise, a website must be constructed to feature the project descriptions and team members of the cooperative programs, so that any one with an interest in a particular project/issue can easily review research on that topic. In addition, annual reports on each research program shall be provided at the website and in paper form. Customers can easily see what has been accomplished and comment on how the program can be improved.

PROSPECTS

Meeting Emerging Challenges of Biotechnology

Voluminous reports and information are available addressing issues and concerns on biotechnology. Agricultural biotechnology will undoubtedly play a major role in the creation of products to meet the emerging demand in agriculture. People around the world have developed and are using many kinds of biotechnology. Traditional biotechnology applications have been around for millennia, including manipulating microorganisms in the fermentation process to make bread, beer, wine, soy sauce, cheese and many other food products. It is not until the emergence of molecular biology, that the rapid development of modern biotechnology reached a ground-breaking advancement because of its enormous power to transform living things. New techniques such as tissue culture, cell culture, embryo transfer, animal cloning, as well as various techniques of molecular manipulations and genetic transformation, have emerged and have been widely used. Most prominently, transgenic technologies such as genetically modified organisms/products have been widely used in crop breeding and commercial production.

We can not stop and turn back. Biotechnology is here to stay. For example, the global area planted to genetically modified (GM) crops has been estimated to exceed 80 million ha this year. The rapid expansion of GM crops all over the world has raised public concern. Producers tend to be optimistic about the potential benefits,

and advocate the rapid development and mass production of such crops. Others, however, particularly those who consume the GM products, are concerned about the long-term uncertainty with respect to food safety and the environment. Public acceptance of agro-biotechnology will become universal when products are developed with primary consideration on food safety and quality, health improvement property, and environment-friendly production, among others. More science-based information is needed to unravel such a myriad of concerns and expectation generally brought about by consumers and from the market demand.

I would like to take Taiwan's experience in empowering small-scale farmers for knowledge-based agriculture, as an example, and bring some of my perspectives for your comments, as well as to promote more awareness of the potential benefits of agro-biotechnology research for consideration in our future cooperative program. In reality, as the global economy becomes knowledge-based, the utilization of information and technology will increasingly drive agricultural development. In recognition of the importance of the development of agro-biotechnology, Taiwan has made it a priority to maximize the practical applications of improved technologies at the farm level in the past. Now, the government has likewise expanded efforts to promote commercialization of biotechnology products. Information about basic research in agro-biotechnology needed to be brought to the public domain. Thus, the government now aggressively undertakes research and development initiatives related to biotechnology. Research findings with potential for further application are transferred to the private sector and farmers through various extension channels, either through government agencies or farmers' associations. So far, research findings on agro-biotechnology developed by the public sectors, particularly from the agricultural research institutes, have been applied to production in many ways. These include tissue culture for the production of healthy seedlings, breeding improvements, bioagents (biofertilizer, biopesticide), vaccines, and food processing, among others. Furthermore, to gear up for both research and commercial development, five biotech science parks have been set up by the public sector in different locations around the island. The biotech science parks offer incentives for private companies to join in future efforts to produce and market agricultural biotechnology products. Taiwan's experience in the development of agro-biotechnology, to a greater extent, could benefit not only small-scale farmers and medium enterprises (SME) in the island, but through regional cooperation, the small-hold farmers in the Asian and Pacific region as well. In addition, it is highly desirable that projects listed in the cooperative program should develop a good complementary linkage with the NARS (National Agricultural Research System), but duplications with the NARS' ongoing projects must be avoided.

Like the member countries in the Asian-Pacific Economic Cooperation (APEC), Taiwan is especially interested in the potential of agro-biotechnology to reduce costs and increase productivity and profitability. For example, APEC Ministers specifically addressed biotechnology at its 9th APEC Ministerial Meeting held in Vancouver, Canada in 1997. They asserted that biotechnology "offers the promise of greater food security, safer environments, and enhanced economic development." The APEC joint statement included the following:

> "Recognizing the vital contribution that biotechnology can make toward expanding agricultural and food production, Ministers encouraged the Agricultural Technical Cooperation Experts Group to intensify science-based approaches to the introduction and use of biotechnology products."

Furthermore, in 1999, APEC Leaders in Auckland recognized the important contribution that biotechnology can make in expanding agricultural production, and requested recommendations for future work. Until now, the ATCWG (Agricultural Technical Cooperation Working Group) has listed "Research, Development and Extension of Agricultural Biotechnology" as one of its thrust areas for its work/action plans. All these emphasize our interest and close involvement in the promotion of biotechnology for use in agriculture. I still can recall vividly, as Lead Shepherd of the APEC/ATCWG, the diverse views concerning scientific information on biotechnology. But finally, at the end of the meeting, a consensus was reached to list biotechnology related issues as part of the ATCWG work plans for regional cooperation. Since the USA and Taiwan are members of APEC, our bilateral cooperation in agricultural sciences, which listed biotechnology as one of its priority areas, has had a regional implication and significance.

Strengthen Transgenic Research for Greater Application in Biotechnology

In the midst of trade liberalization and globalization, simply increasing productivity is not necessarily the answer to meet new challenges for agricultural development. High value growth in agriculture by adopting new technologies will be derived from diversification into production of new value varieties/products for emerging market demands. In recognizing this trend, the 21st century will be the century of biotechnology. Biotechnology can play a major role in promoting the growing value of agriculture and in meeting new demands.

You are all more knowledgeable on the potential of biotechnology. So, just allow me to illustrate to you a remarkable case about how Taiwan's scientists have made a breakthrough in animal cloning technology. A team of scientists from the Livestock Research Institute, the National Taiwan University, the National Chung-Hsing University, and the National Pingtung University of Science and Technology have successfully cloned a dairy goat, named Paoyu in March 2004, making her Taiwan's first transgenic cloned goat that carried a foreign gene – a human coagulating blood Factor 8 – in its genome. She has since grown into a healthy goat. Remarkably, the cloned mother Paoyu was impregnated successfully through natural methods in November 2004 and gave birth to a kid in late April 2005. The kid, named Paopei, which carried the same foreign gene deliberately inserted into her mother, has now grown healthy. Both the cloned mother goat Paoyu and the kid Paopei marked a new milestone in Taiwan's animal cloning history. The scientists are jubilant at the birth of Paopei, now growing normally, because it proves that a transgenic cloned goat can reproduce naturally. The

breakthrough in animal cloning technology has given Taiwan headway in opening up new opportunities and challenges in the application of biotechnology.

Enhanced Research Approaches in Potential New Frontiers to Meet Emerging Demands

1. Streamline project management and timely review of cooperative program

I am glad to note that, after reviewing the reports and minutes of the meetings of the cooperative programs, the annual implementation of the projects was very much consistent with the agreed upon priorities of the collaboration program. I noted that the research topics I proposed and which were agreed upon in 2000, which was my final year of involvement in the cooperative program, had been incorporated in the collaboration program, such as the studies on health-related factors like antioxidants in vegetables and fruits, and control of notorious quarantine insect pest like fruit flies. I am likewise pleased to see and would like to applaud the efforts made by both sides for their timely response to the needs of the changing times, and for identifying priority areas not only for current implementation but for redefining directions for future cooperation. I believe that after this workshop, the cooperative program will even be better equipped to refine its vision to look into more challenge areas of research and development for future cooperation in agricultural sciences, particularly in the sphere of agro-biotechnology toward biosafety and quality.

2. Tapping new areas to meet emerging demands

The most recent bilateral meeting between TECRO and AIT on cooperative program in the agricultural sciences was held on 19 April 2005. As in the past, each year, more new specific priority areas are identified to further redefine cooperative research efforts in subject areas described in the Amendment in the Guidelines for the Cooperative Program in Agricultural Sciences between AIT and TECRO. In this year's discussion as recorded in the minutes, the consensus for both sides is to cooperate on the following 2006 priority areas for 2006:

- Genetic engineering of plants and animals and related assessment, management, communication, detection and standards accession;
- Application of bio-chips in agriculture;
- Micronutrients;
- GM regulation;
- Introduction of preventative and diagnostic technique on zoonosis; and
- Plant functional genomics research.

3. Additional areas for future cooperation

To my view, with respect to future priorities for cooperation beyond 2006, research efforts on such areas as genetic transformation of rice crop for enhancing dietary fiber, bio-farming, bio-material research, and soil-rhizosphere system must be pursued.

Genetic Transformation of Rice Crop to Enhance Dietary Fiber

It may be a bit of a wild thinking but I imagine it would be highly beneficial to people with rice as their staple food – to be eating rice which is high in dietary fiber. Similarly, an excellent example of increased nutritional content in foods was nicely exemplified by the breeding success of "golden rice" – the introduction of genes for the production of beta carotene into rice. Although rice is one of the most common crops grown worldwide, it lacks Vitamin A. Consumption of the new variety of rice could help millions of people fight various aspects of Vitamin A deficiency. Importantly, rice is the major staple for many areas of the world. From health aspects, the transformation of rice variety to contain dietary fiber will undoubtedly increase its value for human consumption. Research indicates that a diet high in fat and sugar and low in dietary fiber is damaging to the health, and can result to many diet-related illnesses.

Innovative Approach to Biofarming/ biopharming

Research in biofarming or more specifically biopharming has been addressing widely the potential implications of agro-biotechnology. This type of molecular farming technology involves modifying plants and animals from transgenic genes to produce specific molecules that can be extracted via processing and refinement after production to produce therapeutic proteins, vaccines, and industrial enzymes. This may be a small tonnage market, but the value per unit of weight can be very high. More researches are needed to tap the potential of biofarming/biopharming.

Modern Approaches to Bio-material Research

Bio-material research is another emerging area in the sphere of biotechnology. This refers to harnessing naturally occurring compounds, enzymes, and microbes by molecular tools to enable the production of renewable materials and fuels, and keep the environment clean through biodegradable approach. In addition, many researchers advocate that bio-materials produced from crops will form the foundation for the next generation of hydrogen-based fuel cells for transportation and power generation, and a range of applications not yet developed.

Unraveling the Myth of Soil-rhizosphere System for Efficient Crop Production and Fertilizer Use

Good soil-rhizosphere system is the basic condition to ensure good crop production and quality. To maintain good growth condition, more studies need to be conducted to monitor and identify optimal conditions for soil- rhizosphere system, and cost-effective fertilizer use.

CONCLUSION

In the past two decades, 99 cooperative projects have been conducted by scientists and researchers from both sides, which have yielded many valuable results in terms of both basic and applied studies in agriculture, particularly in the context of agricultural biotechnology. With respect to future priorities for cooperation, both the TECRO and AIT sides have reached a consensus during their bilateral meeting in Taipei, to cover genetic engineering of plants and animals and its related risk assessment, management, communication, detection and standards accession; application of bio-chips in agriculture; micronutrients; GM regulation; introduction of preventative and diagnostic techniques on zoonosis, and plant functional genomics research. This list does not exclude cooperation in other areas such as those identified in the Guidelines for the Cooperative Program. This reiterates the importance that biotechnology has been employed and will play a major role in the science-based improvement of agriculture.

The application of biotechnology to agriculture creates great challenges as well as opportunities. Agriculture is the foundation of many societies in the Asian and Pacific region, and Taiwan is no exception. It serves, not only as a provider of food and livelihood, but also as a very important source of social and economic stability, and a dynamic interaction between human beings and ecosystem. However, like Taiwan, the majority of farmers in the Asian region are engaged in small-scale farming. Their access to new information and technology is relatively poor. Production is labor-intensive. It has been my thinking for some time – that it is possible that the significant results of many of the past US-Taiwan bilateral collaborative research projects could be built into a mechanism of transferring technology and knowledge gained through regional cooperation. Another possibility is to utilize the long-standing Taiwan Agricultural Technical Mission as a stepping stone to transfer technology and assist the agriculture sectors of developing countries. The TECRO-AIT agricultural science cooperation projects pose much benefit of regional implications. In addition, given the current trends in globalization and trade liberalization, the small-hold farmers need to be able to take advantage of new technical developments, since they are competing with big farmers all over the world. Through such regional cooperative efforts, information about appropriate biotechnology may be extended and transferred as needed to countries primarily dependent on small-scale farming.

It is a delightful opportunity for me to participate in this workshop, and to join you in celebrating the 20th year anniversary of the TECRO-AIT Cooperative Programs in Agricultural Science. The locomotive of biotechnology train is running fast and I anticipate seeing you in the next workshop catching up on this trend in not too far future.